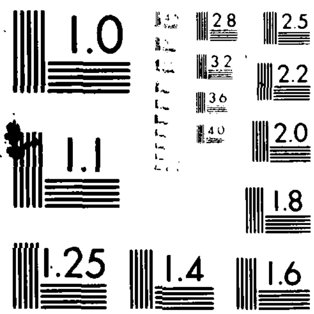
AD-A110 137 MITRE CORP MCLEAN VA METREK DIV F/G 17/7
OVERVIEW OF THE O'HARE RUNWAY CONFIGURATION MANAGEMENT SYSTEM.(U)
SEP 81 R L FAIN DTFA01-81-C-10001
UNCLASSIFIED MTR-81W235 FAA-EM-82-5 NL

1 of 1
AD
A110137

END
DATE
FILMED
3 82
DTIC




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Report No. FAA-EM-82-5

MTR-81W235

(12) LEVEL II



# OVERVIEW OF THE O'HARE RUNWAY CONFIGURATION MANAGEMENT SYSTEM

RICHARD L. FAIN

The MITRE Corporation
McLean, Virginia 22102

(12) 52



SEPTEMBER 1981

Document is available to the U.S. public through
the National Technical Information Service
Springfield, Virginia 22161



Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
OFFICE OF SYSTEMS ENGINEERING MANAGEMENT
Washington, D.C. 20591

409890

## N O T I C E

Technical Report Documentation Page

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| FAA-EM-82-5 | AD-A110137 | |

| 4. Title and Subtitle | 5. Report Date |
|---|---|
| Overview of the O'Hare Runway Configuration Management System | September 1981 |
| | 6. Performing Organization Code |
| 7. Author(s) | 8. Performing Organization Report No. |
| Richard L. Fain | MTR-81W235 |
| 9. Performing Organization Name and Address | 10. Work Unit No. (TRAIS) |
| The MITRE Corporation<br>Metrek Division<br>1820 Dolly Madison Blvd.<br>McLean, Virginia 22102 | 11. Contract or Grant No.<br>DTFA01-81-C-10001 |
| 12. Sponsoring Agency Name and Address | 13. Type of Report and Period Covered |
| Department of Transportation<br>Federal Aviation Administration<br>Office of Systems Engineering Management<br>Washington, D. C. 20591 | 14. Sponsoring Agency Code<br>AEM-100 |

15. Supplementary Notes

16. Abstract

The O'Hare Runway Configuration Management System (CMS) is an interactive computer algorithm designed to assist the Assistant Chief of the O'Hare facility in selecting runway configurations which minimize delay. The current version of CMS utilizes a full screen input/output structure to enhance near-term implementation within O'Hare's manual ATC environment. This paper presents an overview of the runway selection logic (including the impacts of transitioning between configurations and balancing demand) and describes the system hardware configuration and the functional responsibilities of the participants in the O'Hare application. The historical development of CMS, future potential enhancements in system logic and system implementation, and application of CMS at other airports are also discussed.

| 17. Key Words | 18. Distribution Statement |
|---|---|
| Runway Configuration<br>Terminal Flow Management<br>Airport Capacity<br>Air Traffic Delay Reduction<br>Interactive computer algorithm | Document is available to the public through the National Technical Information Service, Springfield, VA 22161 |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | | |

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

## TABLE OF CONTENTS



RE: Report No. FAA-EM-82-5
Page 1-2 does not contain proprietary
information per Ms. Even Hill, FAA/Library

## LIST OF ILLUSTRATIONS

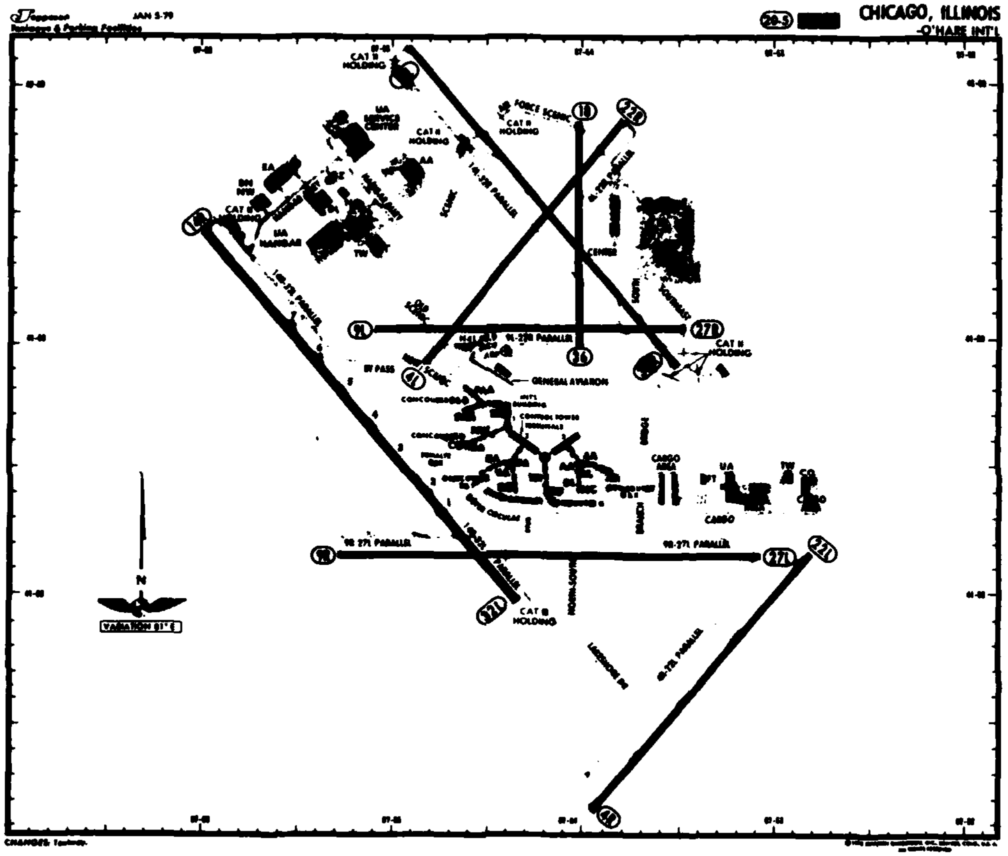
## LIST OF ILLUSTRATIONS
(Concluded)

## 1. INTRODUCTION

The O'Hare Runway Configuration Management System (CMS) is an interactive computer algorithm designed to aid supervisory personnel of the combined O'Hare tower/TRACON facility in the consistent selection of runway configurations which reduce delays by maximizing throughput capacity in dynamically changing operational environments. This document presents an historical perspective and functional overview of the most recent version of CMS which has been developed by The MITRE Corporation under the sponsorship of the Office of Systems Engineering Management of the Federal Aviation Administration (FAA) for near-term implementation at O'Hare.

The O'Hare system is the first site specific application of a national program called Terminal Area Configuration Management (TACM). TACM encompasses not only runway selection but also includes management of terminal airspace and ground side resources (reference 1) and can, therefore, be tailored to suit the specific operational needs of any major airport. In turn, TACM is a key program of the FAA's Integrated Flow Management program which concerns the global optimization of traffic flow throughout the entire ATC system.

At O'Hare, the runway configuration selection process is compounded by the complexity of the runway layout (Figure 1-1) and the dynamic nature of airport operations. The airport has twelve main runway ends and a short runway (18/36) which is used occasionally for general aviation traffic under visual conditions. Using only the twelve main runways, there are seventy-three runway configurations that use at least two arrival runways and two departure runways simultaneously and that have been identified as operationally feasible. In addition, there are a myriad of runway combinations that include fewer runways. Furthermore, the airport's role as a major connecting link for domestic and international air traffic creates large fluctuations during the day in the volume and distribution of traffic over each of its arrival and departure fixes. In addition, the rapid changes in wind and weather conditions which are prevalent in the Chicago area further increase the complexities of the runway selection. These problems, plus those common to all major airports (runway closures, equipment outages, etc.) make CMS a particularly useful tool for O'Hare in minimizing aircraft delay.




BASE DRAWING PROVIDED BY
JEPPESEN & CO.
ILLUSTRATION ONLY—NOT TO BE
USED FOR NAVIGATIONAL PURPOSES

**FIGURE 1-1**
**CHICAGO O'HARE INTERNATIONAL AIRPORT LAYOUT**

In today's environment, the assistant chief (AC) of the shift on duty at the O'Hare facility has primary responsibility for making runway selection decisions. Such decisions are based on a diverse set of airport status and traffic demand indicators and generally require extensive coordination with team supervisors of both the tower cab and the TRACON. CMS offers a means to consolidate and display information relevant to the decision process and to automatically integrate this information into a measure of capacity for evaluating alternative configuration choices. CMS also provides the AC with a powerful tool in planning transitions between the currently active configuration and those feasible in a forecast set of conditions.

There are a number of companion documents which serve to comprehensively document the current O'Hare system. One set of forthcoming documents will give highly detailed descriptions of the CMS program including representations of logic flow. The User's Guide (reference 2) instructs users of CMS in how to access and operate the system as implemented on an IBM 4341 time-share computer with IBM 3277 equivalent terminals configured as shown in Section 4.1. The O'Hare Test Plan (reference 3) outlines how the test and evaluation of CMS at O'Hare could be conducted on a time-share system.

The historical chain of events prompting the development of CMS is presented in Section 2 and is followed in Section 3 by a description of the runway configuration management concepts which guided the development. Section 4 describes both the physical layout of CMS hardware and the functional interactions of CMS users as envisioned for near-term implementation at O'Hare. Finally, Sections 5 and 6 respectively discuss future enhancements that would increase the operational productivity of CMS and the changes that would be necessary to adapt the O'Hare system for use at other major airports.

## 2. HISTORICAL PERSPECTIVE

The initial impetus for developing a runway configuration management system for O'Hare was the finding of the O'Hare Delay Task Force Study which began in December 1974 to identify the causes and potential solutions to air traffic delays at Chicago. The task force concluded in its report of July 1976 (reference 4) that development and implementation of a terminal management plan which utilized optimal runway configuration selection could realize potential cost savings of between $11M and $16M dollars annually. The subsequent development of CMS is summarized in Figure 2-1.

Following the publication of the task force finding, FAA Great Lakes Region (AGL) requested FAA headquarters for assistance in developing an operational system. The MITRE Corporation, in support of both the FAA Office of Systems Engineering Management (OSEM) and the Air Traffic and Airway Facilities Services (ATF), was tasked to do the development and in November 1977 the first project meeting was held at Chicago.

In February 1978, MITRE presented the initial concepts for an evolutionary three level runway configuration management system to the Director of AGL and to ATF. MITRE was then directed to begin development of the first level "basic" system.

By February 1979, the basic level of computer software had been developed for what was now officially designated as the O'Hare Runway Configuration Management System (CMS). Its design was that of an interactive computer algorithm which could provide a list of preferred runway configurations for any fixed set of operational inputs. The basic design was intended to provide a modular foundation for adding subsequent time-dynamic enhancement associated with the second level 'intermediate' system and the third level 'advanced' system. The basic system was installed at the O'Hare Tower for 30 days of preliminary testing and evaluation and, as a result, several modifications were suggested along with the recommendation that the system software development should continue to evolve toward the intermediate level concepts (primarily the incorporation of transition effects and airspace considerations). In May 1979, MITRE formally published the first paper presenting the tri-level concepts of runway configuration management and the O'Hare application (reference 5).

**1976**

O'Hare Delay Task Force publishes findings

AGL request assistance from ATF
OSEM in support of ATF tasks
MITRE to develop a runway management system

**1977**

Project initiation meeting at O'Hare

**1978**

Initial concepts briefed to AGL and ATF

Development of 'basic' system

First demonstration of basic system to O'Hare

Refinements to basic system

**1979**

Test and Evaluation at CMS at O'Hare

Overlay version of CMS developed

Results of T&E; Concept paper published

T&E results incorporated in CMS

AGL requests development toward 'intermediate' system

**1980**

Demand balancing concepts defined
Transition concepts defined

Future Enhancements Study published

**1981**

Demand balancing and transition logic programmed
Full screen I/O, multi-terminal concept incorporated
Functional implementation defined

Documentation of current system published

**FIGURE 2-1**
**HISTORICAL DEVELOPMENT OF CMS**

By mid 1980, the airspace logic and associated software had been added to account for the distribution of traffic demand over the arrival and departure fixes. During the latter part of 1980 with funding support from the Transportation System Center, MITRE surveyed and recommended technical enhancements to CMS to guide the FAA's decision with respect to future developments at O'Hare and other major airports (reference 6). Work also focused on developing the conceptual and logical designs for incorporating demand balancing and transition impacts into the existing system. By October 1980, the demand balancing software had been developed and was successfully integrated into the CMS program.

During 1981, work on CMS concentrated on three areas -- refining and programming the demand balancing and transition logic, improving the manual interface and preparing for the test and evaluation. Several new algorithms were designed and tested which would make both the linear programming formulation of the transition analysis and the demand balancing analysis computationally more efficient. In both cases, efforts met with success and were adopted in the CMS software. To further reduce the manual workload, MITRE also decided during 1981 to completely overhaul the input/output structure to take advantage of recent advances in full-screen, menu type displays which would allow inputs directly on status display screens. At the same time, provisions were made for a multi-terminal implementation which would distribute the input responsibilities to those personnel in the O'Hare TRACON and cab currently responsible for monitoring and reporting changes in airport conditions (described in Section 4 of this document). The third area involved the development of computer specifications, cost estimates, and a survey of computer systems (commercial time-share vendors and dedicated minicomputers) suitable for testing and evaluating CMS prior to implementation.

The culmination of all these efforts is the version of CMS that is described in this and the companion documents. Future work will be guided by recommendations coming from future demonstrations, tests and evaluations of CMS and by the enhancements discussed in Section 5.

## 3. THE CONCEPT OF RUNWAY CONFIGURATION MANAGEMENT

Runway configuration management addresses the issue of how to dynamically choose combinations of runways at an airport which will minimize aircraft delays for a given sequence of changes in the airport's operational environment. By its very nature, runway selection is a complex process being influenced not only by whims of nature (changes in wind and weather) but also by many operational factors as illustrated in Figure 3-1. A change in any one of these many variables can have significant influence on aircraft delays. Figure 3-2 demonstrates the impact of the percentage mix of arrivals and departures on total capacity. As the demand pattern changes from one consisting predominantly of departures to one consisting predominantly of arrivals, the best choice of runway configurations to minimize potential delays changes dramatically. While the experience and proficiency of supervisory air traffic controllers cope admirably with such complex problems, there is a need for an automated aid which can assist the supervisor in the consistent selection of high capacity runway configurations. This need for such an aid becomes more acute in a rapidly changing environment.

Figure 3-3 identifies the elements that make up the runway configuration management process. The solid lines indicate the components of a single transition system which incorporates the capacity impacts of changing from a runway configuration operating under a set of current conditions to all configurations eligible under one future set of operating conditions. The dashed lines indicate the logical extension of the single step system into one involving multiple transitions. The multiple step system can determine optimal runway configuration selection strategies over an extended planning horizon involving more than one set of forecast changes in the operating environments. The runway configuration management system under development at O'Hare is, at this point in time, a single-transition system with plans to enhance the design to include multiple transitions in the future. This enhancement is discussed in more detail in Section 5.

The first step in runway configuration management is to define the respective current and forecast scenarios. This is accomplished in the current scenario by insuring that the system is continually aware of all changes in the current operating environment. Ideally, this would be done automatically by interfaces with existing monitoring systems available in the tower and TRACON facilities. In a manual environment such as that at O'Hare, the input functions can be delegated to those

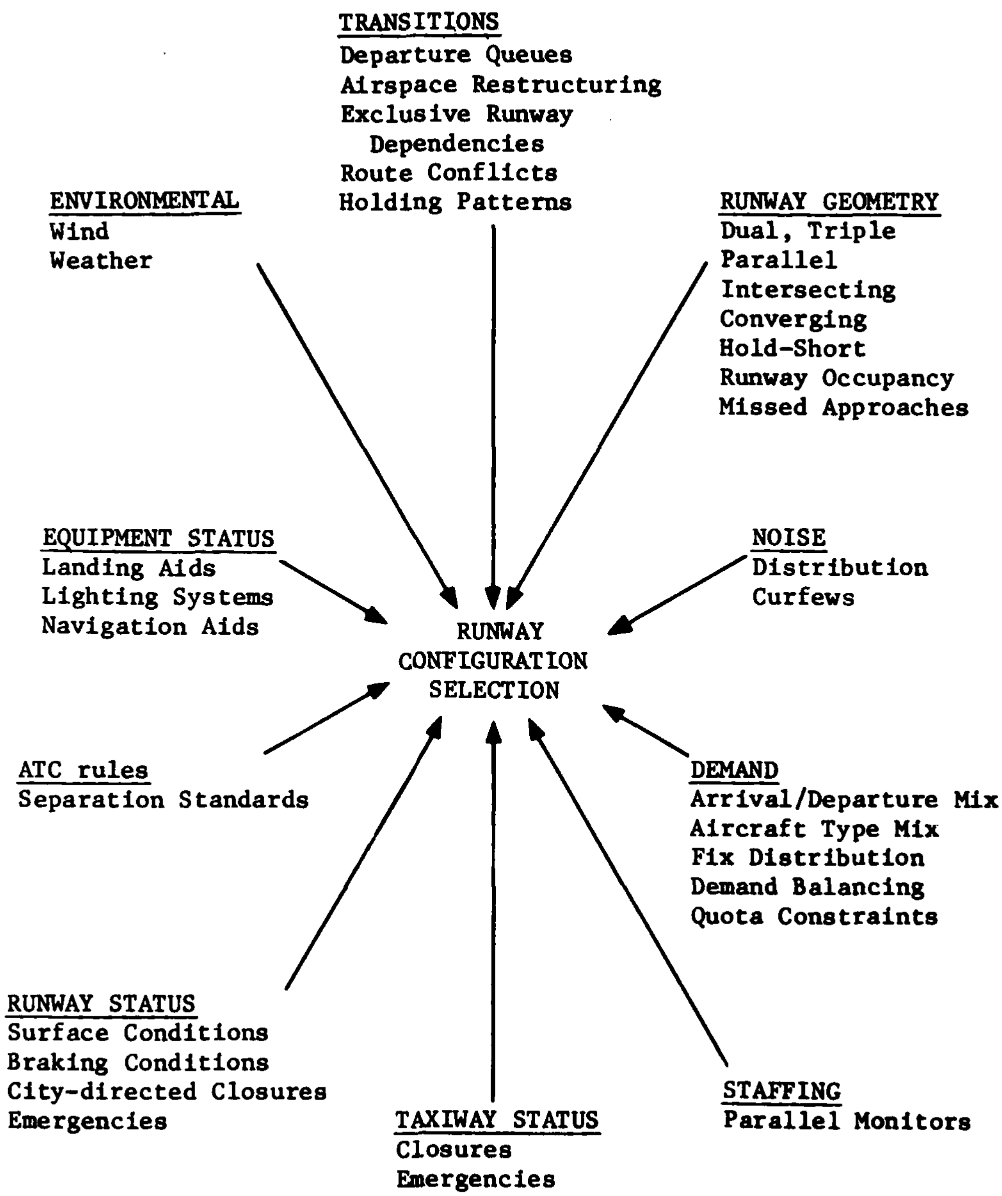



**FIGURE 3-1**
**INPUTS TO RUNWAY CONFIGURATION SELECTION**

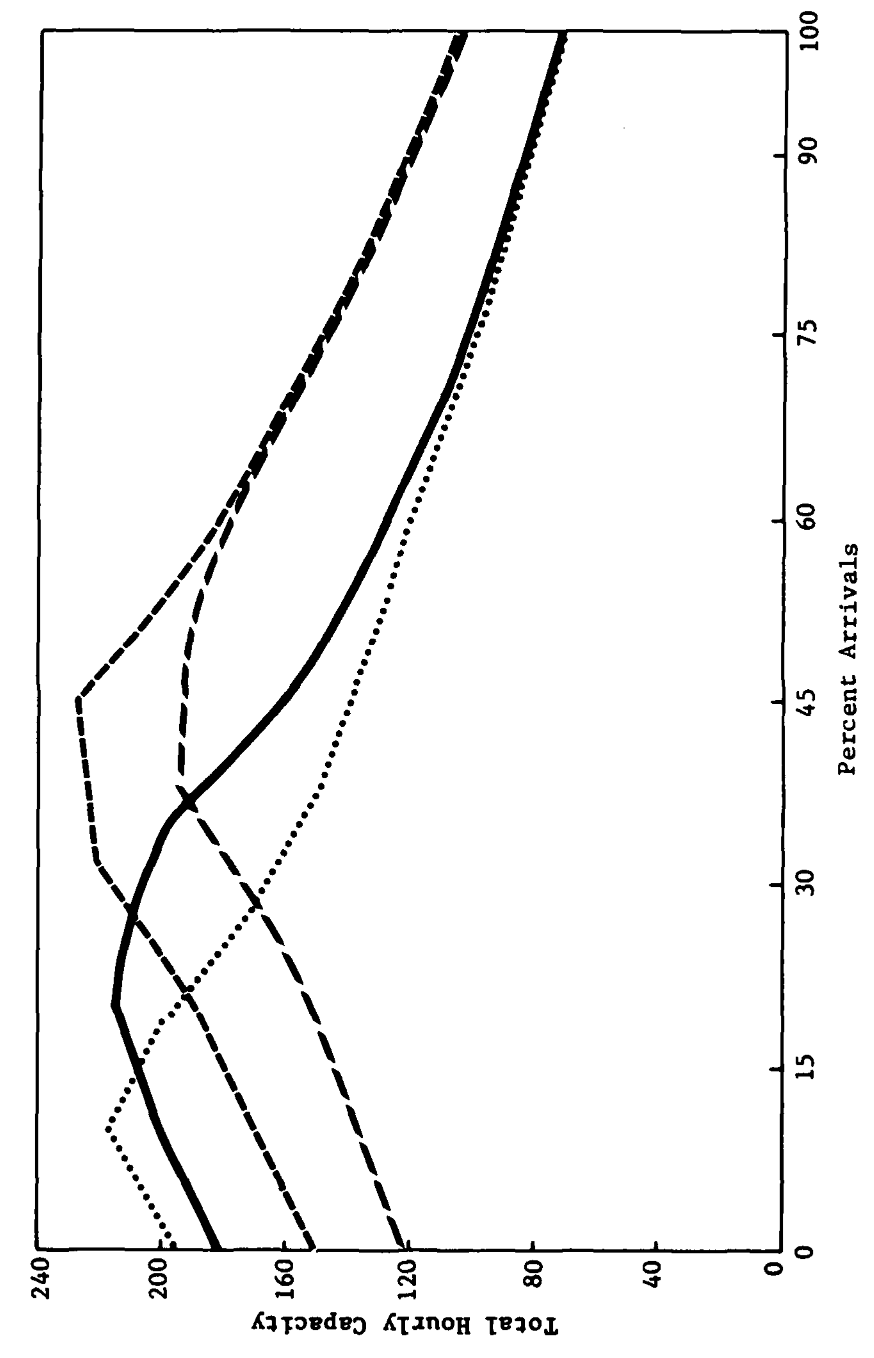



**FIGURE 3-2**
**VFR CAPACITY CURVES FOR FOUR TYPICAL O'HARE CONFIGURATIONS**

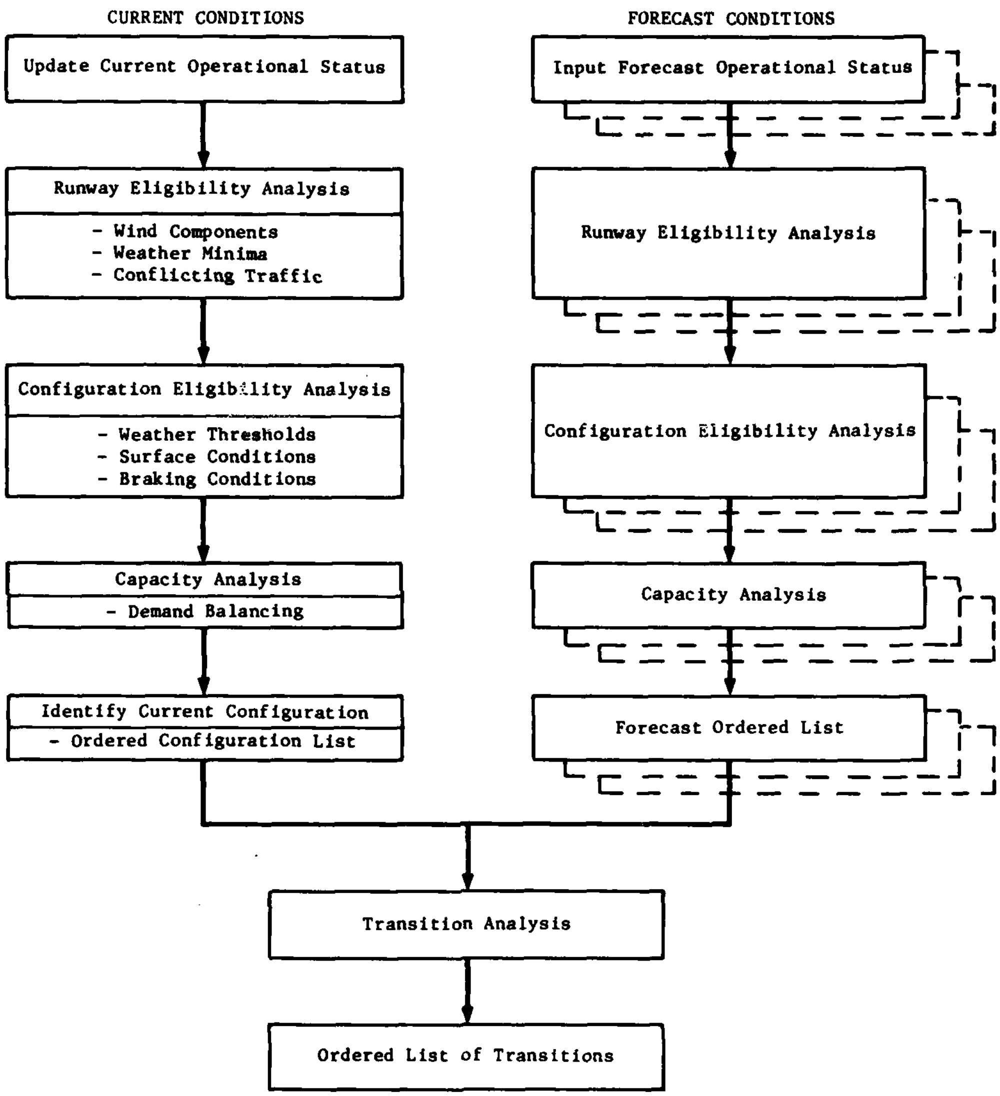



**FIGURE 3-3**
**MAJOR ELEMENTS OF RUNWAY CONFIGURATION MANAGEMENT**

persons who now have responsibility for monitoring, reporting and recording the information without imposing much, if any, additional workload. The operational description in Section 4 describes how this might be done at O'Hare.

The forecast scenarios record changes in the operational environment expected to occur in the future which may be significant enough to warrant a change in runways. In an automated environment some forecast information could be input to the system by interfaces with National Weather Service communication lines for wind and weather forecasts and with NAS, ARTS and Central Flow computer systems for expected traffic demand information. Manual inputs can be delegated to the same parties responsible for maintaining the current operational status or they can be left to the supervisor responsible for deciding runway changes. The latter option gives the supervisor freedom to use the system as a planning tool with which he can evaluate the consequences of different courses of action. In the application at O'Hare, only the assistant chief (AC) is permitted to construct future scenarios, however, the O'Hare system allows the other participants (Airway Facilities operations office and cab team supervisors) to communicate future events (runway closures, planned maintenance) to the AC by a system of interconnected planning logs (described in Section 4).

Based on the updated inputs, the next step within each scenario determines the operational availability of individual runways. Runways may be closed to arrivals and/or departures for a variety of reasons: city-directed closures for construction and maintenance, aircraft emergencies, excessive crosswinds or tailwinds, or ceiling or visibility below published minima. Ceiling and visibility minima are, in turn, a function of runway equipment outages (instrument landing systems, navaids and lighting systems). Runway preference and availability may also be influenced by traffic at nearby airports such as when 13R is being used for arrivals at Midway Airport.

The runway configurations remaining after the deletion of ineligible runways are then checked for operational suitability. Some runway geometries require that prevailing ceiling and visibility conditions exceed certain thresholds. For example at O'Hare, non-parallel arrivals can only be operated in conditions better than 800 ft ceiling and 2 nmi visibility. Configurations in which arrivals must hold short of intersecting active arrival and departure runways are also subject to stringent ATC rules regarding runway surface and braking conditions.

The capacity analysis for each feasible runway configuration remaining after the initial screening process is conducted in two parts. The first redistributes the demand over the north and south complexes so as to equalize saturation levels (demand divided by capacity) on each runway. Demand balancing mimics the airport's actual procedure of rerouting traffic within the terminal area in order to equalize controller workloads and to minimize the need to hold aircraft. Using the arrival/departure ratios for each operationally independent group of runways within the configuration resulting from the demand redistribution, capacities are calculated for each group for the respective weather and braking conditions and appropriate ATC rules.

The first level of output within each scenario is the capacity ordered list of available configurations suitable for the respective current and forecast conditions. The ordered list associated with current conditions is particularly useful in identifying the capacity differences between the runway configurations actually in use and others on the list and, depending on the magnitude of the difference, may prompt a transition on its own accord. If transition impacts are of little concern to the decision maker, the current and forecast ordered lists may be compared directly to plan runway transitions.

Up to this point, the runway selection process has been concerned with analyzing configurations within static operating scenarios, that is, for a single set of conditions. With the addition of the transition analysis, the process becomes a dynamic one, being concerned also with the capacity impacts of changing from one configuration to another. The selection strategy then becomes to maximize total capacity over some planning time horizon which includes all the transitions resulting from expected changes in the operational environment. This prevents the selections of successive high capacity configurations whose transition penalties may be so high as to offset the capacity benefits gained with each configuration.

The transition analysis yields the primary output of the runway configuration management system -- an ordered list of transition strategies indicating which runways to use at what times during the planning period.

A runway configuration management system has a number of inherent benefits which supplement its primary purpose of reducing aircraft delays. Most of these serve to reduce workloads in one form or another and are evident in the O'Hare application described in Section 4. The use of multiple terminals to access a common data base provides key personnel in the tower and TRACON facilities with immediate access to displays of the current operational status of the airport. The multiple terminal system also allows, with as much flexibility as desired, direct communication between terminal users. In the O'Hare system, this facility is used primarily to transmit future planning information from the cab and AF operations officer to the AC. These information transfer capabilities can significantly reduce the telephone workload and paperwork normally associated with these functions. Another benefit deriving from having a consolidated data base which continually reflects current and future status of the airport is the automatic and/or selective generation of logs and historical records on system printers. Likely candidates include Performance Measurement System (PMS) reports and equipment logs.

## 4. OPERATIONAL DESCRIPTION OF THE O'HARE SYSTEM

The O'Hare Runway Configuration Management System (CMS) as envisioned for near-term implementation within the O'Hare Air Traffic Control Tower (ATCT) is designed to aid the assistant chief (AC) of the facility in decisions regarding choice of runway configurations. This requires that CMS have access to complete and timely information about all factors affecting runway choice and that this same information be readily available to the assistant chief.

Although in the long run, O'Hare CMS will automatically detect changes in airport conditions through direct interfaces with existing and future monitoring systems, initial implementation is expected to occur within the existing manual ATC environment. Thus, the O'Hare system is both physically and functionally organized in keeping with the current location of inputs with the ATCT and current procedures for monitoring and reporting changes (Table 4-1).

To minimize the impact of manual inputs, CMS uses a sophisticated full screen input/output structure and comprehensive error checking routines. Most operational entries only require moving a cursor to the appropriate position on a formatted screen and entering a single symbol (usually an 'X'). Input/status/output display screens are selected by pushing a single function key. All screens are virtually self-explanatory and require minimal training of users.

### 4.1 Physical Configuration

At a minimum, CMS consists of a central computer supporting at least three keyboard CRT display terminals and one printer (Figure 4-1). One terminal is located in the tower cab, one at the Airway Facilities (AF) operations officer's position in the TRACON and one at the assistant chief's position in the TRACON. Additional display terminals may be added as desired. The printer is located in a room adjacent to the TRACON radar room which has easy access by the assistant chief and the AF representative.

Each terminal allows only a selected set of inputs into CMS consistent with the information for which that terminal position is responsible as defined in Section 4.2. Optional display terminals such as that shown near the TRACON team supervisor position in Figure 4-1 could be restricted to displaying only airport and runway conditions for the informational benefit

## TABLE 4-1
## CMS INPUT AVAILABILITY WITHIN THE O'HARE ATCT

| INPUT | LOCATION | SOURCE | FREQUENCY | LOG | COMMENTS |
|---|---|---|---|---|---|
| Equipment Status: | | | | | |
| LOC, AS, OM, MM, IM, NDB, VOR/DME | TRACON (AF) | status lights | continuous | AF log<br>TRACON worksheet | |
| ALS, RAIL | Cab | status lights | continuous | AF log | |
| RVR | Cab, TRACON | digital readouts | continuous | AF log | |
| HIRL, CL, TDZ, Edge Lights | Cab | City, PIREPS | nightly | | |
| Arrival demano | TRACON | ARTS, $CF^2$, Cab | continuous | hourly totals on PMS | alphanumeric aircraft info listed on ARTS, 10-15 minutes before appearance on scope |
| Departure demand | Cab | FDEP | continuous | hourly totals on PMS | 30 minutes prior to proposed departure time |

TABLE 4-1
(Concluded)

| INPUT | LOCATION | SOURCE | FREQUENCY | LOG | COMMENTS |
|---|---|---|---|---|---|
| Ceiling | Cab, TRACON | NWS electrowriter | hourly, as needed | PMS | supplementary sources: UAL, Chicago FSS, CF[2] |
| Visibility (>4 mi) | Cab, TRACON | NWS electrowriter | hourly & as needed | PMS | |
| Visibility (< 4 mi) | Cab | Cab observations | continuous | PMS | |
| Visibility (< 60 RVR) | Cab, TRACON | RVR | continuous | | |
| Wind Direction & Velocity | Cab, TRACON | NWS centerfield indicator and 7 VAS indicators | continuous | PMS | stored on mag tape for approx 15 days. Selective displays at arrival controller and local controller positions. Summary displays at supervisor positions in Cab and TRACON |
| Braking and Surface Conditions | Cab | City CRT, city telephone, PIREPS | daily, as needed | | |
| City Directed Runway Closures | Cab | City CRT, city telephone | | TRACON worksheet | |
| Midway traffic | TRACON | TRACON | continuous | | TRACON approach control coordinates with Chicago En Route |

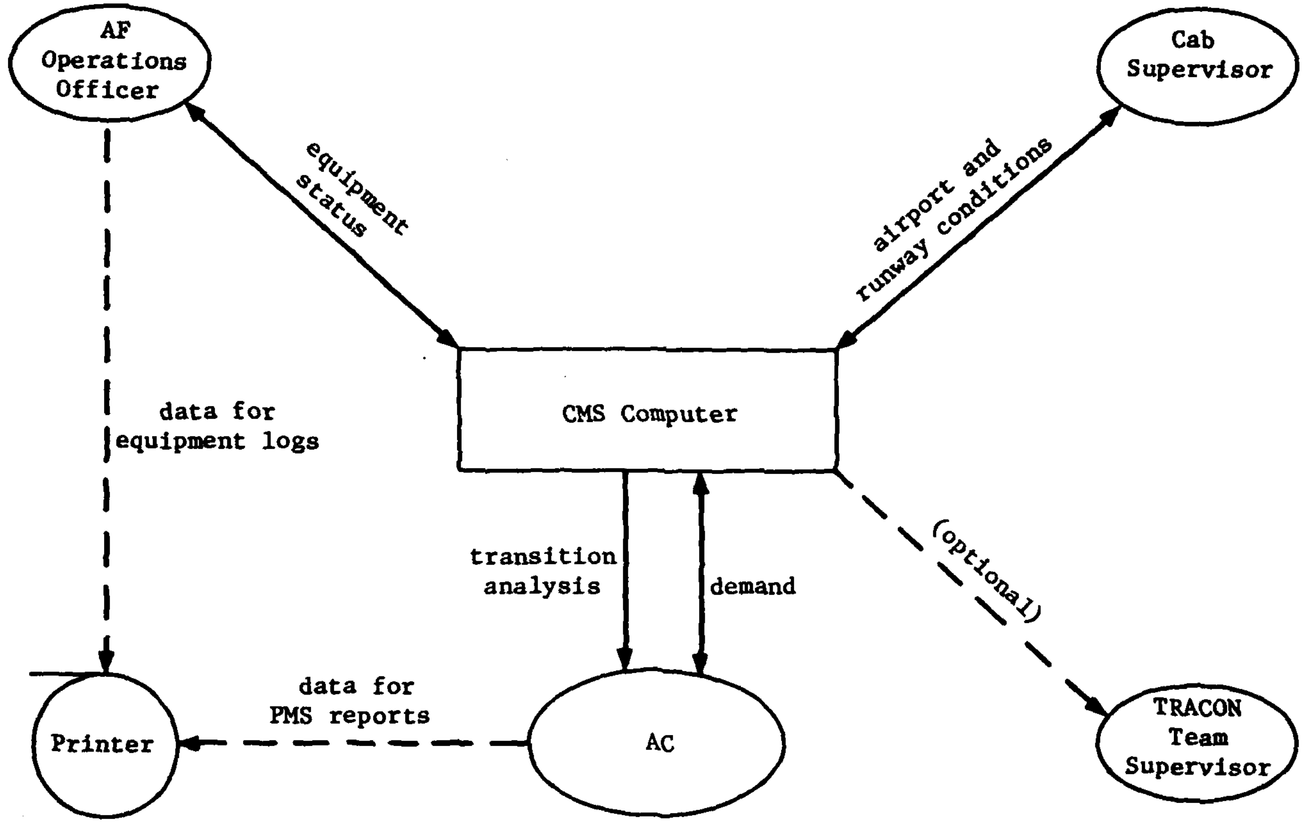



FIGURE 4-1
PHYSICAL CONFIGURATION OF CMS

or it could also function as another input station for the assistant chief since one source of current traffic demand information is directly available on the ARTS III scopes.

The main CMS computer houses the CMS software which controls the interactive input/output displays, maintains the common data base and performs the analytical functions of the system. It also enforces the communications protocol which governs terminal access to the data base and to other terminals.

The printer located adjacent to the radar room has the capability to produce hard copies of any screen displayed at any of the terminals by request. In addition, the printer can be used to generate data relevant to equipment logs, PMS reports and any other information requested by the AC.

## 4.2 Functional Description

In keeping with the physical layout of CMS peripheral equipment at O'Hare, the functional responsibilities are distributed to those tower and TRACON personnel who normally monitor and report changes in the operating environment namely, the assistant chief, the tower cab team supervisor and the AF operations officer. Figure 4-2 diagrams the functional relationships between each participant in the runway configuration selection process and the various CMS input/output display screens.

### 4.2.1 Tower Cab Position

The team supervisor of the tower cab or his designee is primarily responsible for maintaining the current airport status screen (Figure 4-3), for reporting forecast changes on the airport planning log (Figure 4-4) and for inputting departure queue lengths (Figure 4-5) when requested by the AC from sources normally available in the cab. These include National Weather Service (NWS) reports and forecasts of prevailing ceiling, visibility and centerfield wind; tower visibility observations; braking and runway surface reports from the city desk; and city directed closures of runways (maintenance, snow removal, emergencies, etc.). Although cab personnel can display other CMS input/status/output screens, the airport status, the airport planning log and the departure queue length are the only screens which can accept inputs from the cab position.

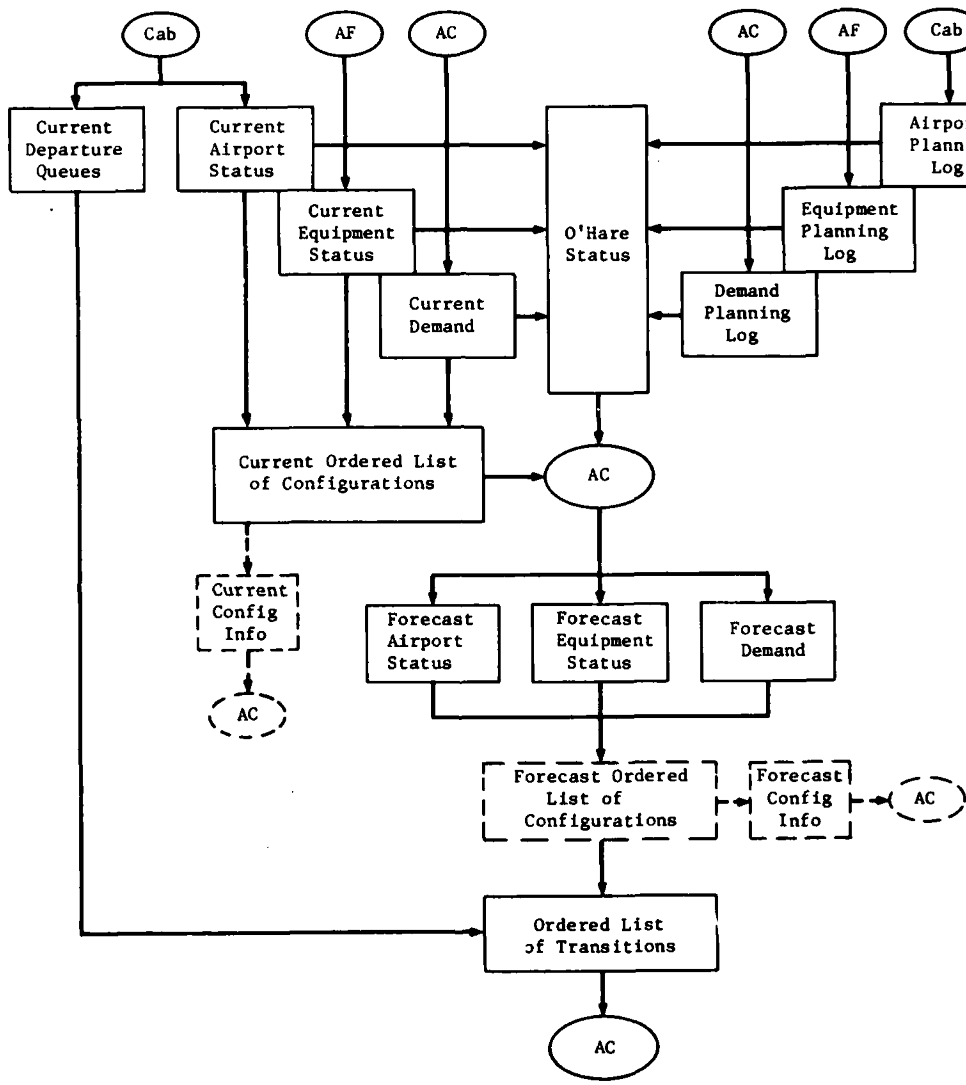



**FIGURE 4-2**
**CMS FUNCTIONAL RELATIONSHIPS**

CURRENT AIRPORT STATUS

CENTERFIELD: WX: CEIL... 5000 VIS... 4.50
WIND: DIR.... 060 VEL... 3

MIDWAY 13R ARR IN USE...

| RWY | TOWER | | SURF | BRK | RVR | WIND | | | | MINIMA | | CLOSED | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ARR | DEP | WET | POOR | | DIR | VEL | CRSS | TAIL | CEIL | VIS | ARR | DEP |
| 4R | | | | | | 060 | 3 | 1 | 0 | 200 | .50 | | |
| 4L | | | | | | 060 | 3 | 1 | 0 | 402 | 1.25 | | |
| 9R | | | | | | 060 | 3 | 1 | 0 | 200 | .50 | | |
| 9L | | | | | | 060 | 3 | 1 | 0 | 200 | .50 | | |
| 14R | | | | | | 060 | 3 | 3 | 0 | 100 | .25 | | |
| 14L | | | | | | 060 | 3 | 3 | 0 | 100 | .25 | | |
| 22R | | | | | | 060 | 3 | 1 | 3 | 200 | 2.00 | | |
| 22L | | | | | | 060 | 3 | 1 | 3 | 200 | .50 | | |
| 27R | | | | | | 060 | 3 | 1 | 3 | 200 | .50 | | |
| 27L | | | | | | 060 | 3 | 1 | 3 | 200 | .50 | | |
| 32R | | | | | | 060 | 3 | 3 | 1 | 200 | .50 | | |
| 32L | | | | | | 060 | 3 | 3 | 1 | 200 | .50 | | |

DATA STORED AT 1322

**FIGURE 4-3**
**AIRPORT STATUS SCREEN**

AIRPORT PLANNING LOG

WEATHER & WIND FORECASTS

| GMT | CEIL | VIS | DIR | VEL | REMARKS |
|---|---|---|---|---|---|
| 1200 | 5000 | 4.50 | 060 | 3 | SCATTERED CLOUDS |
| 1330 | 600 | .75 | 170 | 7 | |

ASST. CHIEF---ADDITIONAL ENTRIES

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

DATA STORED AT 1242

FIGURE 4-4
AIRPORT PLANNING LOG SCREEN

CURRENT DEPARTURE QUEUES

| DEPARTURE RUNWAYS | QUEUE LENGTH |
|---|---|
| 32R | 6 |
| 32L | 4 |

DATA STORED AT 1248

FIGURE 4-5
DEPARTURE QUEUE SCREEN

During normal use of CMS, the current airport status screen remains on display at the cab terminal ready to accept inputs of changes to the airport environment. Entries on this screen immediately update the common data base and impact all subsequent screens displayed at any of the terminal positions. Entries made on the airport planning log indicate expected future changes and are transmitted to the O'Hare status screen (Figure 4-10, Section 4.2.3) for use by the AC in constructing forecast transition scenarios. Planning log entries do not directly affect the forecast airport status screen to which only the AC has input access.

### 4.2.2 Airway Facilities (AF) Position

Similar to the tower cab position, the AF operations officer or his designee located in the TRACON maintains the current equipment status screen (Figure 4-6) and records forecast changes in equipment status on the equipment planning log (Figure 4-7). With the exception of runway lighting systems (the status of which is indicated in the cab), the operational status of equipment is known to the AF officer by way of status light indicators located in the TRACON. Although the AF terminal can display other CMS screens, only the current equipment status and the equipment planning log screens can accept inputs.

In normal usage, the current equipment status screen remains on display at the terminal ready to accept inputs of changes in equipment status. Entries on this screen immediately update the common data base and are reflected in all subsequent screens displayed at any of the terminal positions. Entries of future status changes made on the equipment planning log do not directly affect the forecast equipment status screen, but are transmitted only to the O'Hare status screen for use by the AC in planning future transition scenarios.

The AF representative may at anytime have historical equipment information and periodic equipment logs printed by the CMS printer.

### 4.2.3 Assistant Chief (AC) Position

The assistant chief has the overall responsibility for the operation of the combined tower/TRACON facility at O'Hare and is responsible for decisions regarding runway configuration selection. Consequently, the terminal located at his position in the TRACON allows him, or his designee, to have input/output

CURRENT RUNWAY EQUIPMENT STATUS
(X INDICATES OUTAGE)

| RWY | CAT II | LOC | GS | OM | MM | IM | RAIL | ALS | RVR | HIRL | CL | TDZ | NDB VOR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4R | -- | | | | | -- | | | -- | | -- | -- | -- |
| 4L | -- | | -- | | -- | -- | -- | | -- | | -- | -- | |
| 9R | -- | | | | | -- | | | | | | -- | |
| 9L | -- | | | | | -- | | | | | -- | -- | -- |
| 14R | | | | | | | | | | | | | |
| 14L | | | | | | | | | | | | | |
| 22R | -- | | | | | -- | | | -- | X | -- | -- | |
| 22L | -- | | | | | -- | | | -- | | -- | -- | -- |
| 27R | -- | | | | | -- | | | | | -- | -- | |
| 27L | -- | | | | | -- | | | | | | -- | -- |
| 32R | -- | | | | | -- | | | | | | | |
| 32L | -- | | | | | -- | | | | | | | |

DATA STORED AT 1322

FIGURE 4-6
RUNWAY EQUIPMENT STATUS SCREEN

RUNWAY EQUIPMENT PLANNING LOG

| RWY | EQUIPMENT | OTS | RTS | REMARKS |
|---|---|---|---|---|
| 22R | HIRL | 1200 | 2000 | |
| 14R | LOC | 1400 | 1530 | MAINTENANCE |
| 32L | ALS | 2200 | 2315 | REPAIRS |

ASST. CHIEF---ADDITIONAL ENTRIES

| | | | | |
|---|---|---|---|---|
| | | | | |

DATA STORED AT 1255

FIGURE 4-7
RUNWAY EQUIPMENT PLANNING LOG SCREEN

access to all CMS screens. However, the only screens which concern the current airport status and which are regularly maintained at the AC terminal are the current demand profile (Figure 4-8) and the demand planning log (Figure 4-9). The demand planning log consists of a 24 hour set of prestored hourly fix demand profiles (based on published OAG schedules) which can be modified by the AC to reflect current and expected changes in demand. As with the other planning logs, entries on the demand log do not directly affect other status screens but are used to initialize current (and forecast) demand profile screens. By entering an 'X' in the retrieve field of the current demand screen, CMS extracts the demand for the following hour from the demand planning log prorated between hours as necessary. If necessary, the AC may make additional changes directly on the current demand profile screen. When entered, the common data base is updated and the new demand profile affects all subsequent status screens. All other screens which the AC has exclusive input access to are associated with his use of CMS as a planning aid to assess the impact of either remaining in the current active configuration or of transitioning to another.

When not being used for other purposes, the AC terminal continuously displays the O'Hare status screen (Figure 4-10) which gives an overview of the current operating posture of the airport. This screen not only shows current wind and weather conditions but also shows the capacity relationship of the current runway configuration with respect to the maximum achievable for current conditions. The O'Hare status screen also displays entries made on the airport planning log by the cab and the equipment planning log by the AF representative. Those log entries made since the AC last keyed his terminal are highlighted to draw his attention to new entries that may require some forthcoming action. Highlights remain until the AC acknowledges that he is aware of the entries by pressing the 'acknowledge' key on his terminal.

The AC position is the only terminal which can access those CMS screens associated with planning configuration changes. Any time the AC wishes to determine the relative merit of the current choice of runways with respect to other runway configurations possible within the current environment, he may select to display the current ordered list of configurations (Figure 4-11). This screen shows the current operating configuration as a highlighted entry among all eligible configurations listed in order of decreasing throughput capacity. Operational warnings (such as conflicting Midway

```
CURRENT DEMAND     ( FROM 1317 TO 1417 )

RETRIEVE...

 ARRIVALS:

TOTAL...  57

KUBBS...  14
CGT.....  20
VAINS...  13
FARMM...  10


 DEPARTURES:

TOTAL...  67

NORTH...  19
EAST....  19
SOUTH...  15
WEST....  14

DATA ENTERED AT 1317
```

FIGURE 4-8
CURRENT DEMAND SCREEN

DEMAND PLANNING LOG
(TO INITIALIZE LOG, ENTER "X"...    )

SCROLL    LINES

| GMT | TOTALS ARR | TOTALS DEP | ARRIVALS KUBBS MKE | ARRIVALS CGT PLANT | ARRIVALS VAINS | ARRIVALS FARMM | DEPARTURES NORTH MKE | DEPARTURES EAST | DEPARTURES SOUTH | DEPARTURES WEST |
|---|---|---|---|---|---|---|---|---|---|---|
| 1300 | 63 | 71 | 18 | 21 | 14 | 10 | 20 | 21 | 15 | 15 |
| 1400 | 44 | 56 | 5 | 19 | 10 | 10 | 15 | 15 | 16 | 10 |
| 1500 | 75 | 73 | 21 | 22 | 17 | 15 | 15 | 23 | 15 | 20 |
| 1600 | 57 | 72 | 11 | 16 | 15 | 15 | 21 | 19 | 17 | 15 |

DATA STORED AT 1545

**FIGURE 4-9**
**DEMAND PLANNING LOG SCREEN**

```
******************************************************************************
*                                                                            *
*                              O'HARE STATUS                                 *
*    WX:  CEIL... 5000   VIS... 4.50       WIND:  DIR... 060   VEL...  3     *
*                                                                            *
*     ARR...  4R  9R  9L    DEP... 32R 32L            CAPACITY...  204       *
*                                                                            *
*                CAPACITY AT  94 % OF HIGHEST AVAILABLE CAPACITY             *
*                                                                            *
*                          SCROLL...      LINES                              *
*                                                                            *
*                   **** RECENT CHANGES FROM 1200 ****                       *
*   1200   22R    HIRL        OTS                                            *
*   1200   WX     5000    4.50     SCATTERED CLOUDS                          *
*   1200   WIND    060    3        SCATTERED CLOUDS                          *
*                                                                            *
*                 **** EXPECTED CHANGES THROUGH 2315 ****                    *
*   1330   WX      600     .75                                               *
*   1330   WIND    170    7                                                  *
*   1400   14R    LOC         OTS  MAINTENANCE                               *
*   1530   14R    LOC         RTS  MAINTENANCE                               *
*   2000   22R    HIRL        RTS                                            *
*   2200   32L    ALS         OTS  REPAIRS                                   *
*   2315   32L    ALS         RTS  REPAIRS                                   *
*  DATA STORED AT 1255                                                       *
*                                                                            *
******************************************************************************
```

**FIGURE 4-10**
**O'HARE STATUS SCREEN**

CURRENT ORDERED LIST OF CONFIGURATIONS

TOTAL ARRIVALS... 46 %

NUMBER OF ELIGIBLE CONFIGURATIONS... 73

SCROLL LINES

| RANK | ARRIVALS | DEPARTURES | CAPACITY | REMARKS |
|---|---|---|---|---|
| 1 | 22R 27R 27L | 22L 32L | 221 | DAY ONLY |
| 2 | 4R 9R 9L | 4L 32L | 213 | |
| 3 | 9R 14R 22R | 9L 22L | 211 | DAY ONLY |
| 4 | 4R 9R 9L | 32R 32L | 206 | |
| 5 | 9R 14R 22R | 14L 22L | 199 | DAY ONLY |
| 6 | 9R 14R 14L | 4L 22L | 198 | |
| 7 | 9R 14R 14L | 9R 22L | 191 | |
| 8 | 9R 14R 14L | 9L 22L | 191 | |
| 9 | 14R 14L 22L | 22L 27L | 190 | |
| 10 | 14R 22R 22L | 22L 27L | 188 | DAY ONLY |

DATA STORED AT 1317

FIGURE 4-11
CURRENT ORDERED LIST OF CONFIGURATIONS SCREEN

Airport traffic) associated with each configuration which could influence the selection decision are also displayed on this screen.

To assess the capacity impacts of transitioning to any of the other configurations, the AC may conduct a transition analysis by first defining the operational environment he expects to exist at the end of the transition. This is done by constructing a forecast scenario on airport status, runway equipment status and demand screens similar in format to those used to indicate current conditions (Figures 4-12, 4-13 and 4-14, respectively). If the clearing out of departure queues is expected to affect the transition, the AC may at this time request the cab to enter queue lengths (Figure 4-5, Section 4.2.1). The AC completes the transition analysis by selecting the screen which shows the ordered list of transitions (Figure 4-15). For each configuration which would be eligible in the forecast scenario, this screen displays the total capacity for the first hour after the start of the transition (the transition capacity plus a prorated portion of the capacity of the final configuration) and the hourly capacity of the final configuration.

If the assistant chief does decide to change the runway configuration, he can then indicate his new choice by returning to the current ordered list of configurations screen and entering an 'X' next to its position on the list.

A number of supplemental CMS displays are also available to the AC on his request. The forecast ordered list of configurations (Figure 4-16) lists those configurations eligible under the forecast set of conditions in decreasing order of available future capacity without consideration for transition impacts. A second display called the configuration information display provides detailed capacity, demand, saturation and demand balancing information for any runway configuration in either current or forecast conditions (Figure 4-17). This latter display is useful to the AC in providing acceptance rate information to the en route center in compliance with en route metering guidelines (reference 7).

FORECAST AIRPORT STATUS

CENTERFIELD: WX: CEIL... 600 VIS... .75
WIND: DIR.... 170 VEL... 7

MIDWAY 13R ARR IN USE... X

| RWY | TOWER | | SURF | BRK | RVR | WIND | | | | MINIMA | | CLOSED | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ARR | DEP | WET | POOR | | DIR | VEL | CRSS | TAIL | CEIL | VIS | ARR | DEP |
| 4R | | | | | | 170 | 7 | 5 | 5 | 200 | .50 | | |
| 4L | | | | | | 170 | 7 | 5 | 5 | 402 | 1.25 | X | |
| 9R | | | | | | 170 | 7 | 7 | 0 | 200 | .50 | | |
| 9L | | | | | | 170 | 7 | 7 | 0 | 200 | .50 | | |
| 14R | | | | | | 170 | 7 | 4 | 0 | 100 | .25 | | |
| 14L | | | | | | 170 | 7 | 4 | 0 | 100 | .25 | | |
| 22R | | | | | | 170 | 7 | 5 | 0 | 200 | 2.00 | X | |
| 22L | | | | | | 170 | 7 | 5 | 0 | 200 | .50 | | |
| 27R | | | | | | 170 | 7 | 7 | 1 | 200 | .50 | | |
| 27L | | | | | | 170 | 7 | 7 | 1 | 200 | .50 | | |
| 32R | | | | | | 170 | 7 | 3 | 6 | 200 | .50 | | |
| 32L | | | | | | 170 | 7 | 3 | 6 | 200 | .50 | | |

DATA STORED AT 1304

**FIGURE 4-12**
**FORECAST AIRPORT STATUS SCREEN**

FORECAST RUNWAY EQUIPMENT STATUS
(X INDICATES OUTAGE)

| RWY | CAT II | LOC | GS | OM | MM | IM | RAIL | ALS | RVR | HIRL | CL | TDZ | NDB VOR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4R | -- | | | | | -- | | | -- | | -- | -- | -- |
| 4L | -- | | -- | | -- | -- | -- | | -- | | -- | -- | |
| 9R | -- | | | | | -- | | | | | | -- | |
| 9L | -- | | | | | -- | | | | | -- | -- | -- |
| 14R | X | X | | | | | | | | | | | |
| 14L | | | | | | | | | | | | | |
| 22R | -- | | | | | -- | | | -- | X | -- | -- | |
| 22L | -- | | | | | -- | | | -- | | -- | -- | -- |
| 27R | -- | | | | | -- | | | | | -- | -- | |
| 27L | -- | | | | | -- | | | | | | -- | -- |
| 32R | -- | | | | | -- | | | | | | | |
| 32L | -- | | | | | -- | | | | | | | |

DATA ENTERED AT 1314

FIGURE 4-13
FORECAST RUNWAY EQUIPMENT STATUS SCREEN

```
FORECAST DEMAND     ( FROM 1418 TO 1518 )

RETRIEVE...

  ARRIVALS:

TOTAL...   52

KUBBS...    9
CGT.....   20
VAINS...   12
PARMM...   11


 DEPARTURES:

TOTAL...   61

NORTH...   15
EAST....   17
SOUTH...   16
WEST....   13

DATA STORED AT 1317
```

FIGURE 4-14
FORECAST DEMAND SCREEN

ORDERED LIST OF TRANSITIONS

ARRIVALS... 46 %     NUMBER OF ELIGIBLE CONFIGURATIONS... 8

SCROLL LINES

| RANK | ARRIVALS | DEPARTURES | TRANSITION DUR(MIN) | TRANSITION HOUR CAP | FINAL CAP |
|---|---|---|---|---|---|
| CURRENT | 4R 9R 9L | 32R 32L | -- | 206 | |
| 1 | 9R 9L | 4R 4L 32R | 28 | 184 | 126 |
| 2 | 9R 9L | 4R 4L | 28 | 169 | 126 |
| 3 | 9R 9L | 32R 32L | 28 | 168 | 125 |
| 4 | 27R 27L | 22L 32R 32L | 26 | 168 | 125 |
| 5 | 27R 27L | 22L 32L | 26 | 163 | 126 |
| 6 | 27R 27L | 32R 32L | 26 | 163 | 125 |
| 7 | 32R 32L | 27L 32R 32L | 25 | 161 | 124 |
| 8 | 32R 32L | 27L 32R | 25 | 151 | 119 |

DATA STORED AT 1336

FIGURE 4-15
ORDERED LIST OF TRANSITIONS SCREEN

FORECAST ORDERED LIST OF CONFIGURATIONS

TOTAL ARRIVALS... 46 %

NUMBER OF ELIGIBLE CONFIGURATIONS... 8

SCROLL LINES

| RANK | ARRIVALS | DEPARTURES | CAPACITY | REMARKS |
|---|---|---|---|---|
| 1 | 27R 27L | 22L 32L | 126 | MIDWAY |
| 2 | 9R 9L | 4R 4L 32R | 126 | |
| 3 | 9R 9L | 4R 4L | 126 | |
| 4 | 9R 9L | 32R 32L | 125 | |
| 5 | 27R 27L | 22L 32R 32L | 125 | MIDWAY |
| 6 | 27R 27L | 32R 32L | 125 | |
| 7 | 32R 32L | 27L 32R 32L | 124 | MIDWAY |
| 8 | 32R 32L | 27L 32R | 119 | MIDWAY |

DATA STORED AT 1317

**FIGURE 4-16**
**FORECAST ORDERED LIST OF CONFIGURATIONS SCREEN**

CURRENT CONFIGURATION

| | 4R | 4L | 9R | 9L | 14R | 14L | 22R | 22L | 27R | 27L | 32R | 32L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ARRIVALS | X | | X | X | | | | | | | | |
| DEPARTURES | | | | | | | | | | | X | X |

| | PCT ARR | SAT | ARRIVAL DEM | ARRIVAL CAP | DEPARTURE DEM | DEPARTURE CAP |
|---|---|---|---|---|---|---|
| TOTAL | 46 % | .60 | 57 | 95 | 67 | 111 |
| NORTH | 31 % | .60 | 14 | 23 | 31 | 51 |
| SOUTH | 54 % | .60 | 43 | 71 | 36 | 60 |

10 ARRIVALS MOVED TO SOUTH COMPLEX
3 DEPARTURES MOVED TO SOUTH COMPLEX

DATA STORED AT 1336

FIGURE 4-17
CURRENT CONFIGURATION SCREEN

## 5. FUTURE ENHANCEMENTS

With the advent of CMS as a viable system to reduce aircraft delays, there are a number of enhancements which would make the system significantly more productive in an operational environment. These enhancements can be divided broadly into two categories: 1) system development issues which either expand the capabilities of the current system or which incorporate new concepts in configuration management and 2) interface issues which deal with the interactions of CMS with other components of the air traffic control system. Major CMS enhancements are schematically summarized in Figure 5-1.

### 5.1 System Development Issues

The single most important enhancement to the current version of CMS which would significantly improve its power as a runway selection decision tool is to extend the transition logic to allow multiple transitions over some extended planning period (e.g., a controller shift). The output of CMS would then take the form of transition strategies which would be ordered on the total capacity over the entire planning horizon.

One concept for a multiple transition system utilizes "minimum cost/maximum flow" network logic to incorporate several predicted changes in the operational environment and resulting transition effects throughout the planning horizon. Figure 5-2 depicts the concept of the multiple transition model. the planning horizon consists of 'n' time frames indicated by $t_1$, $t_2$, ..., $t_n$. The nodes of the network consist of sets of 'M' configurations. Each link $(i,j)_k$ from configuration i at time $t_k$ to configuration j at time $t_{k+1}$ represents the capacity of transitioning to and remaining in configuration j in the time period $(t_{k+1} - t_k)$.

In actual applications of this concept, the list of configurations under $t_k$ will be limited only to those configurations feasible under the predicted operating conditions at $t_k$. These feasible configurations will be determined through the existing logic applied to the forecast set of inputs at $t_k$. The transition links will then be defined from each feasible configuration i at $t_k$ to each feasible configuration j at $t_{k+1}$. With the network so defined, an application of "minimum cost/maximum flow" techniques would provide the optimal runway selection strategy over the entire planning horizon.

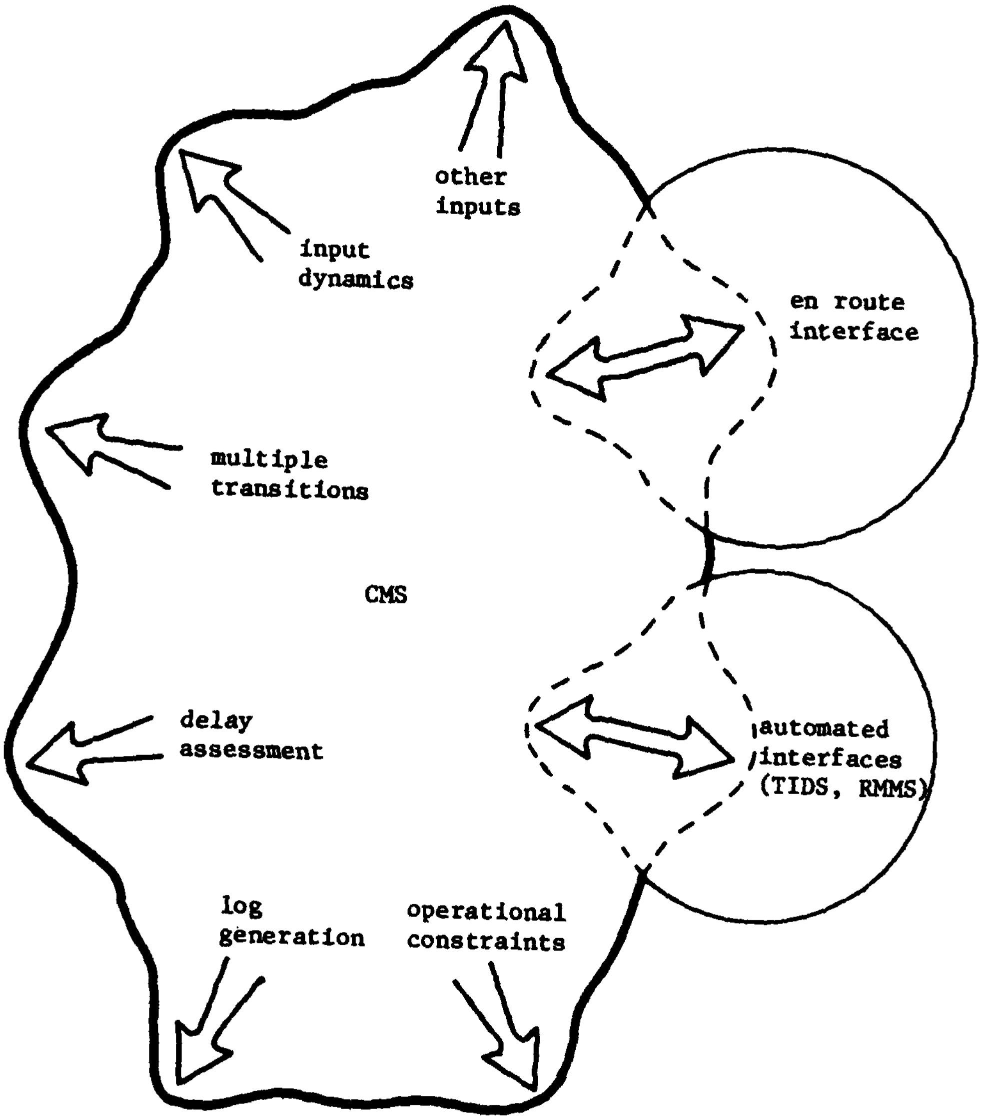



**FIGURE 5-1**
**CMS ENHANCEMENTS**

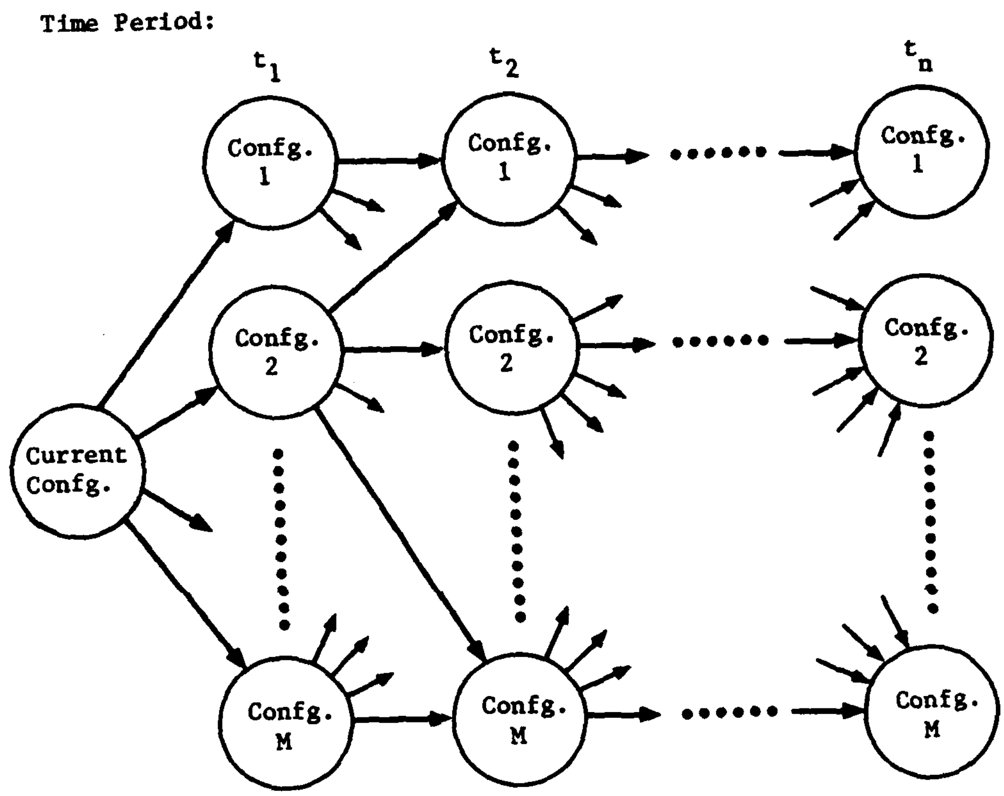



**FIGURE 5-2**
**MULTIPLE TRANSITION NETWORK LOGIC**

Some caution must be exercised in extending the length of the planning horizon in the multiple transition system. As the complexity increases, so do the data requirements and subsequent computing requirements. The conclusions from any such dynamic system are only as good as the quality and reliability of the predicted inputs. A poor set of forecast inputs could actually degrade the output of the system and result in poor or unnecessary configuration changes.

A second area of concern is the development of new input sources required by CMS, but which are not readily available in the tower/TRACON facility and which may not be provided by other proposed information systems (e.g., Terminal Information Display System and Remote Maintenance Monitoring System). Not only will it be necessary to identify the inputs (e.g., expected departure demand), but it will also be necessary to determine how these inputs can be made available as either automated or manual inputs to CMS.

Input dynamics is another area which requires new research. Initial efforts would be to investigate the characteristic changes of inputs over time (especially wind and weather), and the robustness (stability) of configurations with respect to input fluctuations. This work would then be extended to determine if the expected duration of configuration use can be forecast based on the current (immediate historical) behavior of operational inputs. This work is crucial to configuration selection to prevent choosing configurations which may offer high capacity but which are unstable.

Another area of interest to configuration management is to pursue the relationship between capacity and delay. While capacity is a useful inverse measure for ranking configuratons with respect to expected delays, it is not a satisfactory measure of the absolute differences which are needed to assess the actual benefits gained from choosing one configuration over another.

There is also a need to develop and incorporate criteria for several other factors which affect runway configuration selection, but which are not presently considered by CMS. Such factors include the impacts of noise contraints imposed by local municipalities, staffing requirements (such as extra monitors during parallel approaches), and missed approaches. Another area to be resolved is the need to include degenerate configurations (configuration with less than two arrivals and two departure runways) in the list of configuration choices. One approach to this last problem is to devise an algorithm that

can generate and calculate capacities for configurations composed only of the remaining eligible runways whenever all major configurations have been deleted.

Finally, there are several related uses of CMS which can yield immediate benefits by taking advantage of the system's consolidated and continually updated data base to replace or supplement tasks currently being performed in the tower/TRACON. The automation of Performance Measurement System (PMS) reports and equipment logs would be simple to provide. Another possibility would be to use the data base as a source for Automatic Terminal Information Service (ATIS) reports.

## 5.2 Interface Issues

Resource planning systems such as CMS not only provide near-term delay benefits to airports such as O'Hare, but are cornerstones of the FAA's Integrated Flow Management (IFM) program which links both en route and terminal traffic flow programs in order to globally minimize fuel consumption and aircraft delays. The recent advent of CMS (providing terminal acceptance rates and demand distribution information to the en route centers) and en route metering (providing real-time traffic information to the terminal) provides the first real framework for studying en route - terminal relationships and for establishing the communication and coordination that will be necessary to optimize traffic flow.

In addition to the inputs that will be generated by the en route interface (e.g., fix demand), it will also be necessary to design interfaces to provide the other automated inputs required by CMS, including those already available in the tower/TRACON facility (e.g., Runway Visual Range (RVR), equipment status monitors and weather conditions) and those to be provided by FAA Research and Development programs such as the Terminal Information Display System (TIDS) and the Remote Maintenance Monitoring System (RMMS). The obvious benefit to automation of inputs is the elimination of the requirement for a continuous human interface. This not only significantly reduces the workload of making manual inputs to CMS but it also reduces the need for continuous monitoring of input sources.

## 6. APPLICATION AT OTHER AIRPORTS

From the beginning, CMS software has been designed with a highly modular structure to facilitate both its evolutionary development and its eventual application at airports other than O'Hare. To as large an extent as possible, site specific information has been confined either to data files which reside outside the main program logic or to program modules that can be easily replaced. As discussed in reference 1, adaptation of the O'Hare CMS software to other airports is only appropriate if management of runway resources is a major emphasis in the application of terminal area configuration management at that site.

Specifically, the software changes necessary to adapt the O'Hare system must be made in three areas -- data files, input/output screens and program logic modules. Several data files are used to define specific physical and operational characteristics of the airport including

- runway identifiers and operating minima for various equipment status conditions,
- feasible runway configurations,
- fix-to-runway assignments for each configuration,
- capacity curves for each configuration under different operating scenarios (VFR, IFR, hold short, poor braking, etc.),
- nominal travel times between fixes and runways,
- exclusive dependencies between all possible pairs of active arrival and departure runway operations under different operating scenarios,
- 24 hour profiles of the nominal hourly demand at the fixes, and
- central data base of current and forecast airport conditions.

Formats and headings for tabular CMS input/output screens (shown in Section 4) reflect the O'Hare environment and would need to

be modified accordingly. Screens which would be significantly affected include

- current and forecast airport status,
- current and forecast runway equipment status,
- current and forecast demand profiles,
- demand planning log, and
- current and forecast configuration information.

In addition, there are several program logic modules which are also unique to O'Hare operations. In particular, those dealing with

- eligibility of hold short configuration,
- converging arrival minima, and
- demand balancing between north and south runway complexes

would need to be replaced. Some modifications may also be necessary to modules which manipulate the data file information specific to O'Hare.

It should also be noted that, as with any site specific implementation, there are additional concerns that go beyond software adaptation which may directly affect both the physical and functional implementation of CMS. At O'Hare, the tower cab and TRACON are combined into one facility under the common supervision of the assistant chief (whose desk is located in the TRACON) who is primarily responsible for runway configuration selection. However, at many other major airports, the tower and TRACON are separate operational entities, both geographically and organizationally, in which runway selection is done by one facility, usually the tower, and coordinated by phone with the other. There may also be variations in the location and availability of inputs to CMS (particularly with respect to lighting system status and runway conditions from the local municipality). All of these factors will influence both the physical arrangement of CMS peripherals as well as the functional distribution of input responsibilities. For example, one typical application might require that the runway selection planning terminal (equivalent to the AC's terminal at O'Hare) be

located at the tower for use by the tower supervisor. Airport status and planning information would likely continue to be input on another terminal located in the tower cab. Remote terminals at the TRACON and AF facilities would be used to update traffic demand and runway equipment status/planning information respectively. Reassignment of screens to different terminals would also require some minor CMS software changes and may require some changes in the communications protocol of the system. However, the benefits of CMS attributed to workload reduction (Section 3) because of enhanced interfacility communication are greatly increased when facilities are separated.

## APPENDIX A

## REFERENCES

1. A. N. Sinha, "Concepts for Terminal Area Configuration Management," MP-81W31, The MITRE Corporation, September 1981.

2. S. Kavoussi and M. Segal, "User's Reference Guide for the O'Hare Runway Configuration Management System," WP-81W536, The MITRE Corporation, September 1981.

3. R. Hentz and R. Fain, "Outline of a Test Plan for the O'Hare Runway Configuration Management Sytem," WP-81W557, The MITRE Corporation, September 1981.

4. Federal Aviation Administration, "O'Hare Delay Task Force Study," Volumes I-III, FAA-AGL-76-1, July 1976.

5. A. N. Sinha and R. L. Fain, "Runway Configuration Management System Concepts," MP-79W18, The MITRE Corporation, May 1979.

6. R. L. Fain, S. Kavoussi, and G. Scot, "Enhancements to the O'Hare Configuration Management System," Volumes I and II, WP-80W997, The MITRE Corporation, December 1980.

7. Federal Aviation Administration, "Local Flow Traffic Management - En Route Arrival Metering," FAA Order 7100.87, May 1981.